WHAT IS CLAIMED IS:

1. A wave energy converter (WEC) comprising:

a shell mounted about a piston forming a combination which when placed in a body of water is responsive to waves in the body of water for producing relative motion between the shell and the piston;

a mechanical motion to electrical energy converter, including an electric generator, responsive to the relative motion between the shell and the piston for producing electrical power at an output of the electric generator;

means coupling a load to the output of the electric generator;

wherein the shell has a length, L, and the electric power produced at the output of the electric generator is a function of the length of the shell and the depth (Dw) of the body of water in which the WEC is placed; and wherein, as the length of the shell increases from zero to a value equal to Dw, the electric power produced at the output of the generator increases to a maximum value and then decreases; and wherein the length of the shell is selected to produce at least a predetermined power output for certain conditions of the waves.

2. The WEC as claimed in claim 1, wherein the length of the shell is selected to be no less than 0.3Dw and no greater than 0.7Dw.

3. The WEC as claimed in claim 1, wherein the optimum length, L, of the shell is determined by empirically solving the following equation:

$$L = \frac{1 - \cosh(2\pi L/\lambda) + \tanh(2\pi D_w/\lambda)\sinh(2\pi L/\lambda)}{(4\pi/\lambda)\sinh(2\pi L/\lambda) + (4\pi/\lambda)\tanh(2\pi D_w/\lambda)\cosh(2\pi L/\lambda)}$$

where:

D_w = water depth; and
λ is a solution to the equation $\lambda=(gT^2/2\pi)\tan(2\pi D_w/\lambda)$.

4. The WEC as claimed in claim 1, wherein the optimum length (L) of the shell is determined by solving the following equation for values of L ranging from zero to Dw:

   $P_{MAX} = \rho g^2 H^2 TA\, \delta^2/(32\pi L)$
   Where:
   - ρ= is the density of the mass within the shell of the buoy;
   - g= gravity;
   - H= to the wave height peak to trough;
   - T= period of wave;
   - A= the area of the buoy normal to the surface of the water; and
   - δ= $1 - \cosh(2\pi L/\lambda) + \tanh(2\pi D_w/\lambda)\sinh(2\pi L/\lambda)$.

5. The WEC as claimed in claim 1, wherein the length of the shell has a value approximately equal to the value of L for which maximum output power is obtained.

6. A wave energy converter (WEC) comprising:

a shell mounted about a piston forming a combination which when placed in a body of water is responsive to waves in the body of water for producing relative motion between the shell and the piston;

a mechanical motion to electrical energy converter, including an electric generator, responsive to the relative motion between the shell and the piston for producing electrical power at an output of the electric generator;

means coupling a load to the output of the electric generator, said load having an impedance whose value is a function of the period of the waves and of the mass of the water in the shell; and

wherein the shell has a length, L, and wherein the electric power produced at the output of the electric generator is a function of the length of the shell.

7. The WEC as claimed in claim 6, wherein the electric power produced at the output of the electric generator is a function of the length of the shell and the depth (Dw) of the body of water in which the WEC is placed; and wherein, as the length of the shell increases from zero to a value equal to Dw, the electric power produced at the output of the generator increases to a maximum value and then decreases; and wherein the length of the shell may be selected to produce at least a predetermined power output for certain conditions of the waves.

8. The WEC as claimed in claim 7, wherein the length of the shell is selected to be no less than 0.3Dw and no greater than 0.7Dw.

9. The WEC as claimed in claim 7, wherein the optimum length of the shell is determined by empirically solving the following equation:

$$L = \frac{1 - \cosh(2\pi L/\lambda) + \tanh(2\pi\, D_w/\lambda)\sinh(2\pi L/\lambda)}{(4\pi/\lambda)\sinh(2\pi L/\lambda) + (4\pi/\lambda)\tanh(2\pi\, D_w/\lambda)\cosh(2\pi L/\lambda)}$$

where:
D_w = water depth; and
λ is a solution to the equation $\lambda=(gT^2/2\pi)\tan(2\pi\, D_w/\lambda)$.

10. The WEC as claimed in claim 2, wherein the optimum length (L) of the shell is determined by solving the following equation for values of L ranging from zero to Dw:

$$\mathbf{P_{MAX} = \rho g^2 H^2 T A\, \delta^2/(32\pi L)}$$

Where:

ρ= is the density of the mass within the shell of the buoy;
g= gravity;
H= to the wave height peak to trough;
T= period of wave;
A= the area of the buoy normal to the surface of the water; and
δ= $1 - \cosh(2\pi L/\lambda) + \tanh(2\pi\, D_w/\lambda)\sinh(2\pi L/\lambda)$.

11. A WEC as claimed in claim 6, wherein the impedance of said load is approximately equal to 1/ (ω)(C_E)for optimizing the generator power output; where:

ω is equal to the angular frequency of the waves expressible as $2\pi/T$ where T is the period of the waves; and

C_E is approximately equal to MT/K , where MT is approximately equal to the mass of the shell and the mass of the water moved by the shell and K is an electromechanical coupling constant.

12. A WEC as claimed in claim 7 wherein one of the shell and the piston is relatively stationary and the other one of said shell and piston moves in response to said waves.

13. A WEC as claimed in claim 8, wherein the mechanical motion to electrical converter includes a motor which is responsive to mechanical forces due to said relative motion between the shell and the piston for driving the electric generator and producing electrical energy proportional to said relative motion, which electrical energy is applied to said load.

14. A WEC as claimed in claim 9 wherein said load is primarily resistive.

15. A WEC as claimed in claim 10 wherein the portion of the WEC producing a voltage at the output of the electric generator exhibits one of an inductive and capacitive reactance, and wherein said means coupling the load to the output of the electric generator includes a reactive element exhibiting the other one of an inductive and capacitive reactance for enhancing the generation of a resonant condition in the power generation of the WEC.

16. A WEC as claimed in claim 11 wherein the equivalent impedance of the shell and piston and the mechanical motion to electrical energy converter is primarily capacitive and wherein the reactive element coupling the load to the output of the converter includes an inductive element (L) whose reactance (ωL) is approximately equal to the reactance [1/ (ω)(C_E)] exhibited at the output of the electric generator for enhancing the generation of a resonant condition.

17. A WEC as claimed in claim 8 wherein the shell has a tubular shape and the piston moves up and down within the tubular enclosure.

18. A WEC as claimed in claim 8 further including a controller for varying the impedance of the load for maintaining the value of the load seen by the generator equal to an optimum value (RLOPT) for optimum power transfer.

19. A WEC as claimed in claim 8 further including a controller for varying the inductive element for maintaining the system in resonance as a function of changes in at least one of the amplitude, frequency and phase of the waves.

20. A WEC as claimed in claim 8 wherein said inductive element includes at least two different inductive components switchably interconnected to selectively increase or decrease the inductance in the power loop.

21. A WEC as claimed in claim 8 further including a sensor for sensing at least one of the conditions of the waves and the status of the WEC system and a controller responsive to signals from the sensor for varying the values of at least one of the load and the inductive element for maintaining an optimum value of load and enhancing resonance of the system.

22. A wave energy converter (WEC) comprising:

a shell mounted about a **piston** forming a combination which when placed in a body of water is responsive to waves in the body of water for producing relative motion between the shell and the piston;

a mechanical motion to electrical energy converter, including an electric generator, responsive to the relative motion between the shell and the piston for producing electrical power at an output of the electric generator;

means coupling a load to the output of the electric generator; and

wherein when the body of water has a depth, Dw, and the wavelength, λ, of the waves may be expressed as $\lambda=(gT^2/2\pi)\tan(2\pi D_w/\lambda)$, and where Dw/ λ is greater than 1/3, then the length of the shell is made equal to $K\lambda$; where K is a constant less than 1.

23. The wave energy converter as claimed in claim 22, wherein K is equal to 0.2.

24. A method for selecting the length of a tubular shell of a wave energy converter (WEC) to be used in a system, where the tubular shell is mounted about a piston and forms a combination therewith which when placed in a body of water is responsive to waves in the body of water for producing relative motion between the tubular shell and the piston and where the WEC includes a mechanical motion to electrical energy converter, including an electric generator, responsive to the relative motion between the shell and the piston for producing electrical power at an output of the electric generator, comprising the steps of:

(a) determining the values of power output for $P = \rho g^2 H^2 T A\, \delta^2/(32\pi L)$ as a function of L, where L is the length of the tubular shell, and

Where:

ρ= is the density of the mass within the shell of the buoy;

g= gravity;

H= to the wave height peak to trough;

T= period of wave;

A= the area of the buoy normal to the surface of the water; and

$\delta = 1 - \cosh(2\pi L/\lambda) + \tanh(2\pi D_w/\lambda)\sinh(2\pi L/\lambda)$; and

(b) selecting the value of L providing the best results in view of the power generated and cost of the system.

25. A method for selecting the length of a tubular shell of a wave energy converter (WEC) to be used in a system, where the tubular shell is mounted about a piston and forms a combination therewith which when placed in a body of water is responsive to waves in the body of water for producing relative motion between the tubular shell and the piston and where the WEC includes a mechanical motion to electrical energy converter, including an electric generator, responsive to the relative motion between the shell and the piston for producing electrical power at an output of the electric generator, comprising the steps of:

(a) calculating the different values of L as a function of λ and Dw, where

$$L = \frac{1 - \cosh(2\pi L/\lambda) + \tanh(2\pi D_w/\lambda)\sinh(2\pi L/\lambda)}{(4\pi/\lambda)\sinh(2\pi L/\lambda) + (4\pi/\lambda)\tanh(2\pi D_w/\lambda)\cosh(2\pi L/\lambda)}$$

and where:

D_w = water depth; and

λ is a solution to the equation $\lambda = (gT^2/2\pi)\tan(2\pi D_w/\lambda)$.